Article published online: 2025-02-05

Correlation between Severity of Malocclusion and Case Complexity Using Dental Aesthetic Index and ABO Discrepancy Index

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Eur Dent Res Biomater J 2024;5:18–27.

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Abstract

Objective Dentomaxillary abnormalities manifest clinically as malocclusion. Any deviation from normal occlusion is malocclusion. It presents as a malrelationship between the dental arches in one or more planes or deviation in normal individual tooth positions. The present study was done to assess the association between severity of malocclusion and case complexity using the Dental Aesthetic Index (DAI) and American Board of Orthodontics Discrepancy Index (ABO-DI).

Material and Methodology The study was conducted on pretreatment orthodontic records of 120 patients who attended the outpatient department of the orthodontics department to assess the association between severity of malocclusion and case complexity using the DAI and the ABO-DI. Pretreatment orthodontic records used for the study were study casts, lateral cephalogram in occlusion, and orthopantomogram. ABO gauge was used for measuring various parameters on study casts.

Result In all, 3.3% patients had minor or no anomaly (DAI score of $\leq$25), 4.2% patients had definite malocclusion (DAI score of 26–30), 10% patients had severe malocclusion (DAI score of 31–35), 82.5% patients had handicapping malocclusion (DAI score of $\geq$36). In total, 6.7% patients had mild malocclusion (ABO-DI score of $\leq$10), 30% patients had moderate malocclusion (ABO-DI score of 11–20), and 63.3% patients had complex malocclusion (ABO-DI score of $\geq$30).

Conclusion There was a moderate positive correlation between DAI and ABO-DI scores ($p = 0.000$).

Keywords
- malocclusion
- DAI
- ABO-DI
- malocclusion indices
- ABO gauge
- study cast

Introduction

Dentomaxillary abnormalities manifest clinically as malocclusion. Any deviation from normal occlusion is malocclusion.[1] It presents as a malrelationship between the dental arches in one or more planes or deviation in normal individual tooth positions.[2] The present study was done to assess the association between severity of malocclusion and case complexity using the Dental Aesthetic Index (DAI) and American Board of

article published online
February 5, 2025

DOI https://doi.org/10.1055/s-0044-1800819.
ISSN 2791-7452.

Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

Orthodontics Discrepancy Index (ABO-DI).[3] The need for orthodontic treatment is influenced by looking good. Orthodontic treatment results in improvement of functional demand, prevention of tissue damage, and achievement of aesthetic harmony. The terms "complexity" and "severity" are associated with malocclusions, but differences between them exists. The severity of malocclusion refers to the extent to which an occlusion deviates from normal and the degree of orthodontic treatment needed in such cases, whereas the complexity of malocclusion is a measure of effort and skill needed to treat the malocclusion and the difficulty level of the orthodontic case.[4] Using proper tools for the initial diagnosis results in appropriate treatment planning and evaluation.[5] Malocclusion indices are one of these tools. Orthodontic indices play an important role in the classification of malocclusions, orthodontic treatment needs, level of complexity, and prediction of treatment duration and outcome results.[6] Among various malocclusion indices, the DAI was developed by Cons and colleagues in 1986.[7] The DAI measures dental aesthetics to evaluate the relative social acceptability of dental appearance. It provides objective measures of aesthetics and related factors of psychological handicaps.[8] The DAI components are recorded according to the guidelines established by the World Health Organization (WHO).[9] ABO-DI was initially developed in 1998 by team of ABO directors and former directors. Later in 1999, phase III ABO examination, 100 cases were submitted and sored by 2 directors based on which modifications were made in ABO-DI in 2000, 2001, 2002 and 2003. In 2004, Thomas J Cangilosi provided the 13 parameters for scoring of ABO-DI.[10] It is calculated from the observation and measurements taken from the standard pretreatment records, that is, study models (8 traits), lateral cephalogram (3 traits), and orthopantomograms. It helps in the prediction of treatment duration accurately.[11] The present study was conducted to assess the correlation between two widely used malocclusion indices, that is, DAI and ABO-DI, to assess severity and complexity, respectively.

Rationale of the Study

In today's large population, epidemiological indices of malocclusion are an important tool. Hence, this study was performed to find the relationship between severity and complexity of orthodontic cases assessing two indices, that is, DAI and ABO-DI, to screen and prioritize the need for orthodontic treatment.

Aim

The aim of this study was to determine the association between malocclusion severity level and case complexity level of orthodontic cases using DAI and ABO-DI.

Objectives

- To evaluate the severity of malocclusion and orthodontic treatment need in orthodontic cases using DAI.
- To evaluate complexity of orthodontic cases using ABO-DI.

Sample size: Pretreatment orthodontic records of 120 patients. Sample size estimation was done using the following formula:

$$n = \frac{4pq}{I^2}$$

$$n = \frac{4 \times 0.081(1 - 0.081)}{(0.05)^2}$$

$$n = 120.$$

Type of study: This is a retrospective cross-sectional study.

Material and Methods

This study was performed on 120 pretreatment study casts of orthodontic patients within the age range of 14 to 26 years. The samples were scrutinized from the archives of orthodontic records and also of patients attending the outpatient department (OPD) of the department for comprehensive orthodontic fixed mechanotherapy. The measurements were done by the principal examiner.

Selected patients had no previous history of orthodontic treatment or any syndrome present. The materials utilized for the present study comprised ABO gauge (►**Fig. 1**), pretreatment study cast, lateral cephalogram in occlusion, and orthopantomogram.

DAI[12]: The severity of the malocclusion was measured and evaluated using the DAI. Using the 10 parameters from study casts according to the WHO guidelines, the score of each patient's 10 occlusal traits was recorded.

Sl. no.	DAI component
1	Number of missing visible teeth (incisors, canines, and premolars in the maxillary and mandibular arches)
2	Crowding in the incisal segments: 0 = no segment crowded 1 = 1 segment crowded 2 = 2 segment crowded
3	Spacing in incisal segments: 0 = no space 1 = 1 segment spaced 2 = 2 segment spaced
4	Midline diastema in millimeters
5	Largest anterior irregularity on the maxilla in millimeters
6	Largest anterior irregularity on the mandible in millimeters
7	Anterior maxillary overjet in millimeters
8	Anterior mandibular overjet in millimeters
9	Vertical anterior open bite in millimeters
10	Anteroposterior molar relation Largest deviation from normal, either left or right: 0 = normal 1 = half cusp either mesial or distal 2 = one full cusp or more, either mesial or distal

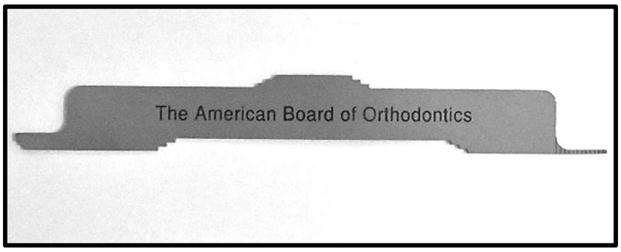

Fig. 1 American Board of Orthodontics gauge.

After recording scores of each occlusal trait, the DAI score was calculated using the regression equation as follows[9]:

"(visible missing teeth × 6) + (crowding) + (space) + (diastema × 3) + (anterior maxillary misalignment) + (anterior mandibular misalignment) + (anterior maxillary overjet × 4) + (anterior mandibular overjet × 4) + (anterior vertical open bite × 4) + (anteroposterior molar relationship × 3) + 13.

The DAI score malocclusion severity treatment needed:

- $\leq$25: minor or no anomaly; no treatment.
- **26 to 30:** definite malocclusion; elective treatment.
- **31 to 35:** severe malocclusion; highly desirable.
- **36 to 70:** handicapping malocclusion; mandatory.

ABO-DI[10]: The level of complexity of orthodontic case was calculated and evaluated using the ABO-DI. It was calculated on dental casts (8 traits), lateral cephalogram, and orthopantomogram. Each element received a score and the sum of all individual scores constituted the total DI score.

Sl. no.	Parameters
1	Overjet: 0 mm (edge to edge): 1 point 1–3 mm: no points 3.1–5 mm: 2 points 5.1–7 mm: 3 points 7.1–9 mm: 4 points > 9 mm: 5 points Negative overjet (anterior crossbite): score is recorded as 1 point/mm for each anterior tooth in crossbite
2	Overbite: Up to 3 mm: no points 3.1–5 mm: 2 points 5.1–7 mm: 3 points If the mandibular incisors are impinging on the palatal tissue (100% overbite), 5 points are scored
3	Anterior open bite: Edge to edge relationship (overbite 0): 1 point each mm of open bite: 2 points
4	Lateral open bite: 2 points are scored per millimeter open bite
5	Crowding: 1–3 mm: 1 point 3.1–5 mm: 2 points 5.1–7 mm: 4 points > 7 mm: 7 points
6	Occlusal relationship: Class I to end-on: 0 points

(*Continued*)

Sl. no.	Parameters
	End-on class II or class III: 2 points per side Full class II or class III: 4 points per side Beyond class II or class III: 1 point per millimeter
7	Lingual posterior crossbite: 1 point per tooth
8	Buccal posterior crossbite: 2 points per tooth
9	ANB angle: Greater than 5.5 or less than −1.5: 4 points Each additional degree: 1 point
10	Sn-Go Gn angle: 27–37 degrees: 0 points > 37 degrees: 2 points per degree < 27 degrees: 1 point per degree Between 27 and 37 degrees: no points are scored
11	IMPA angle > 98: 1 point per degree
12	Others

ANB is Anteroposterior position of maxilla and mandible where A is maxilla and B is mandible, SN-GOGN is Cranial base to mandibular plane, IMPA is lower incisor to mandibular plane angle.

ABO-DI score complexity of malocclusion:

- $\leq$10: mild.
- 11 to 20: moderate.
- $>$20: complex.

Results

Reliability of measurements was evaluated for error analysis. It was done by randomly selecting records of 12 patients on which the DAI and ABO-DI measurements were redone by the same examiner (intraobserver error) and by the different examiner (interobserver error), after 4 weeks. The kappa index test revealed statistically insignificant differences between each of the two readings, showing consistency of measurements.

Descriptive statistics was performed to assess the mean and standard deviation of the respective groups. Normality of the data was assessed using the Shapiro–Wilk test. Inferential statistics to find out the difference within and between the groups was done using the Kruskal–Wallis test. Spearman's rank correlation test was done for correlation analysis. The linear regression analysis model was used for estimation of predictors.

Distribution of DAI Score Frequency

The frequencies of DAI score obtained for the study sample (►**Fig. 2**) are the following:

- Four (3.3%) patients had minor or no anomaly with DAI scores of $\leq$25.
- Five (4.2%) patients had definite malocclusion with DAI scores between 26 and 30.
- Twelve (10%) patients had severe malocclusion with DAI scores between 31 and 35.

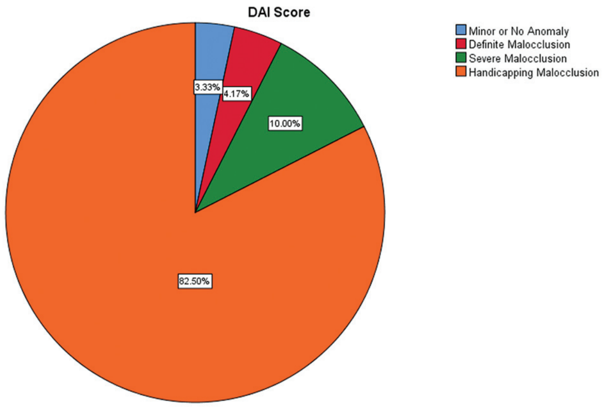

Fig. 2 Pie chart showing frequency distribution of Dental Aesthetic Index (DAI) score.

- Ninety-nine (82.5%) patients had severe malocclusion with DAI scores between 36 and 70.

Distribution of ABO-DI Score Frequency

The frequencies of DAI score obtained for the study sample (►**Fig. 3**) are the following:

- Eight (6.7%) patients had mild malocclusion with a ABO-DI score of $\leq$10.
- Thirty-six (30%) patients had moderate malocclusion with ABO-DI scores between 11 and 20.
- Seventy-six (63.3%) patients had complex malocclusion with ABO-DI scores greater than 20.

Association between DAI and ABO-DI scores with Categorical Variables

Inferential statistics to find out the difference within and between the groups was done using the Kruskal–Wallis test (►**Table 1**).

Out of all the parameters analyzed, only anteroposterior molar relation had a statistically significant difference.

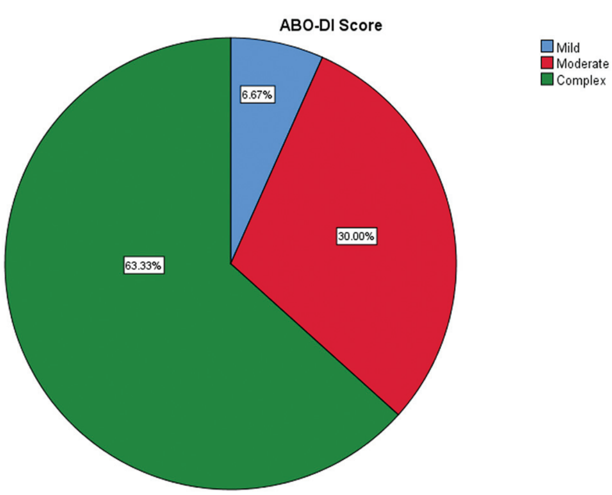

Fig. 3 Pie chart showing frequency distribution of American Board of Orthodontics Discrepancy Index (ABO-DI) score.

Assessment of Correlation between DAI and ABO-DI Sores

Assessment of the correlation between the DAI and ABO-DI scores was done using Spearman's rank correlation.

- Moderate positive correlation was reported (0.426) between the ABO-DI and DAI scores with statistical significance ($p = 0.000$; ►**Table 2**; ►**Fig. 4**).

Estimation of Predictors

The linear regression analysis model was used for estimation of predictors (►**Tables 3–5**).

A p-value less than 0.05 was considered statistically significant.

Linear regression analysis was done to estimate the influence of each parameter (independent variable) on the ABO-DI score (dependent variable) and most of the variables reported significant effect on the dependent variable ($p < 0.05$) except lingual posterior crossbite ($p > 0.05$). The model predicted 78% of change by the independent variables ($R^2 = 0.78$; ►**Table 3**).

The influence of the variables on the ABO-DI score is as follows (highest to lowest):

IMPA angle > SN-GoGn angle> occlusal relationship > crowding > overbite > buccal posterior crossbite > ANB angle > anterior open bite.

A p-value less than 0.05 was considered statistically significant.

Linear regression analysis was done to estimate the influence of the DAI (independent variable) on the ABO-DI score (dependent variable) and reported significant effect on the dependent variable ($p < 0.05$). The DAI predicted 17% of change in the ABO-DI ($R^2 = 0.17$; ►**Table 4**).

Regression equation:

$$\text{ABO-DI} = 11.490 + 0.426 \times \text{DAI}.$$

A p-value less than 0.05 was considered statistically significant.

Linear regression analysis was done to estimate the influence of the ABO-DI (independent variable) on the DAI score (dependent variable) and reported significant effect on the dependent variable ($p < 0.05$). The ABO-DI predicted 17% of change in the DAI ($R^2 = 0.17$; ►**Table 5**.

Regression equation:

$$\text{DAI} = 33.08 + 0.426 \times \text{ABO-DI}.$$

Discussion

Distribution of DAI Score Frequency

In our present study conducted on orthodontic patients, on comparing the DAI scores, it was found that the majority of patients (82.5%) had handicapping malocclusion, while 3.3% patients had a minor or no anomaly. The reason for the high score of handicapping malocclusions was the selection of the study sample from patients having malocclusion attending the OPD of the orthodontic department. Poonacha et al,[13] in

Table 1 Association between DAI and ABO-DI scores with categorical variables

No. of missing visible teeth	Frequency	Percent	ABO-DI score		*p*-value
0	98	81.7	24.33	9.384	0.56
1–3	18	15.0	26.16	10.66	
4–6	4	3.3	28.00	4.32	
Total	120	100.0	24.73	9.45	
Spacing in incisal segments	**Frequency**	**Percent**	**ABO-DI score**		***p*-value**
0	58	48.3	25.01	9.02	0.95
1–3	25	20.8	24.40	8.22	
≥4	37	30.8	24.51	10.99	
Total	120	100.0	24.73	9.45	
Midline diastema	**Frequency**	**Percent**	**ABO-DI score**		***p*-value**
0	115	95.8	24.77	9.44	0.42
1–2	3	2.5	19.33	11.15	
≥3	2	1.7	30.50	7.77	
Total	120	100.0	24.73	9.45	
Crowding in incisal segments	**Frequency**	**Percent**	**ABO-DI score**		***p*-value**
0	33	27.5	22.30	10.15	0.21
1–3	28	23.3	25.25	11.02	
≥4	59	49.2	25.85	8.05	
Total	120	100.0	24.73	9.45	
Largest irregularity in maxilla	**Frequency**	**Percent**	**ABO-DI score**		***p*-value**
0	36	30.0	25.27	10.82	0.65
1–3	56	46.7	23.89	9.22	
≥4	28	23.3	25.71	8.10	
Total	120	100.0	24.73	9.45	
Largest irregularity in mandible	**Frequency**	**Percent**	**ABO-DI score**		***p*-value**
0	25	20.8	23.28	9.74	0.48
1–3	64	53.3	24.54	9.91	
≥4	31	25.8	26.29	8.21	
Total	120	100.0	24.73	9.45	
Anterior maxillary overjet	**Frequency**	**Percent**	**ABO-DI score**		***p*-value**
0	6	5.0	22.00	7.12	0.10
1–3	32	26.7	22.06	9.83	
≥4	82	68.3	25.97	9.28	
Total	120	100.0	24.73	9.45	
Anterior mandibular overjet	**Frequency**	**Percent**	**ABO-DI score**		***p*-value**
0	114	95.0	24.82	9.52	0.64
≥1	6	5.0	23.00	8.43	
Total	120	100.0	24.73	9.45	

Table 1 (*Continued*) Association between DAI and ABO-DI scores with categorical variables

No. of missing visible teeth	Frequency	Percent	ABO-DI score		*p*-value
Vertical anterior open bite	**Frequency**	**Percent**	**ABO-DI score**		***p*-value**
0	117	97.5	24.45	9.38	0.12
1–3	1	0.8	35.00	0.00	
≥4	2	1.7	36.00	7.07	
Total	120	100.0	24.73	9.45	
Anteroposterior molar relation	**Frequency**	**Percent**	**ABO-DI score**		***p*-value**
Normal cusp	62	51.7	21.00	8.71	0.0001*
1/2 cusp	27	22.5	27.03	8.38	
Full cusp	31	25.8	30.19	8.63	
Total	120	100.0	24.73	9.45	

Abbreviation: ABO-DI, American Board of Orthodontics Discrepancy Index.
*indicates $P < 0.05$ is statistically significant.

Table 2 Correlation analysis between age, ABO-DI score, and DAI score

		ABO-DI score
ABO-DI score	Pearson's correlation	
	Sig. (2-tailed)	
DAI score	Pearson's correlation	0.426*
	Sig. (2-tailed)	0.000

Abbreviations: ABO-DI, American Board of Orthodontics Discrepancy Index; DAI, Dental Aesthetic Index.
*indicates $P < 0.05$ is statistically significant.

their study on the population of Vadodara, Gujarat, on randomly selected pretreatment study casts, found that most patients had handicapping malocclusions. In a study on randomly selected junior high schools in the Udupi district, South India, Singh et al[14] found 82% patients had handicapping malocclusions.

On comparison with the study conducted by John et al[15] on school children aged 12 years of higher secondary schools in Chennai, India, it was found that 56.3% children did not require orthodontic treatment, 12.1% children presented with severe malocclusion requiring highly desirable orthodontic treatment, and 6.2% children presented with handicapping malocclusions, requiring mandatory orthodontic treatment as this study was conducted cross-sectionally on all school students.

Distribution of ABO-DI Score Frequency

On comparing the ABO-DI scores in our study, it was found that most patients (63.3%) had complex malocclusion, while

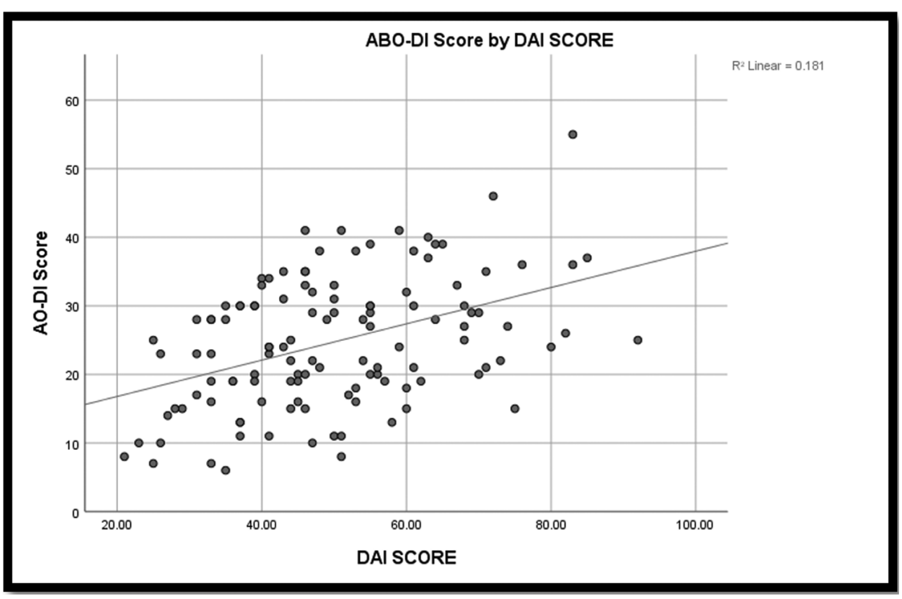

Fig. 4 Correlation between Dental Aesthetic Index (DAI) and American Board of Orthodontics Discrepancy Index (ABO-DI) score.

Table 3 Regression model analysis: (ABO-DI) as dependent variable coefficient (β)

Model summary

Model	R	R^2	Adjusted R^2	Standard error of the estimate	Change statistics				
					R^2 change	F change	df1	df2	Sig. F change
1	0.896[a]	0.803	0.787	4.359	0.803	49.93	9	110	0.000

I. Predictors: (constant), IMPA angle, SN-GoGn angle, occlusal relationship, buccal posterior crossbite, crowding, anterior open bite, ANB angle, lingual posterior crossbite, overbite

Coefficients (β): regression model analysis (ABO-DI score)

Model		Unstandardized coefficients		Standardized coefficients	t	Sig	95.0% confidence interval for B	
1		B	Standard error	Beta			Lower bound	Upper bound
	(Constant)	3.896	1.618		2.407	0.018	0.689	7.103
	Overbite	1.034	0.238	0.208	4.348	0.000	0.563	1.506
	Anterior open bite	0.914	0.339	0.124	2.696	0.008	0.242	1.586
	Crowding	1.069	0.149	0.331	7.176	0.000	0.774	1.364
	Occlusal relationship	1.296	0.183	0.349	7.073	0.000	0.933	1.659
	Lingual posterior crossbite	−1.290	0.836	−0.071	−1.544	0.125	−2.947	0.366
	Buccal posterior crossbite	1.262	0.282	0.203	4.473	0.000	0.703	1.821
	ANB angle	1.152	0.267	0.201	4.318	0.000	0.623	1.681

[a]Dependent variable: ABO-DI score

Abbreviation: ABO-DI, American Board of Orthodontics Discrepancy Index.

Table 4 Regression model analysis (ABO-DI score) as dependent variable and DAI score as independent variable

Model summary									
Model	*R*	R^2	Adjusted R^2	Standard error of the estimate	Change statistics				
					R^2 change	*F* change	df1	df2	Sig. *F* change
1	0.426[a]	0.181	0.174	8.587	0.181	26.11	1	118	0.000
[a]Predictors: (constant), DAI score									

Coefficients (β): regression model analysis for ABO-DI (dependent variable) and DAI (independent variable)								
Model		Unstandardized coefficients		Standardized coefficients	*t*	Sig.	95.0% confidence interval for *B*	
		B	Standard error	Beta			Lower bound	Upper bound
1	(Constant)	11.490	2.707		4.244	0.000	6.129	16.851

Abbreviation: ABO-DI, American Board of Orthodontics Discrepancy Index.
[a]indicates dependent variable (ABO-DI).

Table 5 Regression model analysis (DAI score) as dependent variable and ABO-DI score as independent variable

Model summary									
Model	*R*	R^2	Adjusted R^2	Standard error of the estimate	Change statistics				
					R^2 change	*F* change	df1	df2	Sig. *F* change
1	0.426[a]	0.181	0.174	13.80391	0.181	26.116	1	118	0.000
[a]Predictors: (constant), ABO-DI score									

Coefficients (*β*): regression model analysis (DAI score)								
Model		Unstandardized coefficients		Standardized coefficients	*t*	Sig.	95.0% confidence interval for *B*	
		B	Standard error	Beta			Lower bound	Upper bound
(Constant)		**33.084**	**3.543**		**9.336**	**0.000**	**26.067**	**40.101**
1	AO-DI score	0.684	0.134	0.426	5.110	0.000	0.419	0.949
[a]Dependent variable: DAI score								

Abbreviations: ABO-DI, American Board of Orthodontics Discrepancy Index; DAI, Dental Aesthetic Index.

the least number of patients (6.7%) had mild malocclusion. The reason for the high score of complex malocclusions was the selection of study sample from patients having malocclusion attending the OPD of the orthodontic department. In a study conducted in Indiana, Schafer et al[16] found that patients with a higher DI, that is, increase in the complexity of malocclusion, had a longer treatment.

A study conducted by Pyakurel et al[4] on pretreatment records from Kantipur Dental College, Kathmandu, Nepal, found that the mean DI score increased with an increase in the class of malocclusion. The DI scores for Angle's class I, II, and III were 15.41, 19.86, and 25%, respectively. In their study, the highest DI scores were for cephalometric measures and the lowest scores were for the lingual posterior crossbite.

Association between ABO-DI Scores and Categorical Variables of DAI

Number of Missing Visible Teeth

No statistically significant difference was reported between the number of visible missing teeth in each DAI category and ABO-DI scores ($p = 0.56$). Eighteen patients (15%) had one to three missing visible teeth. Four patients (3.3%) had four to six missing visible teeth. In a study conducted by Plaza et al[6] on the population of Colombia, association was found between missing visible teeth and ABO-DI scores ($p = 0.0012$). The known etiology for missing visible teeth could be congenital missing, impacted, or extracted teeth. In our present study, the reasons for missing visible teeth were more of congenitally missing and impacted teeth.

Crowding in the Incisal Segments, Largest Irregularity in the Maxilla and Mandible

No statistically significant difference was reported between crowding in the incisal segments, largest irregularity in the maxilla and mandible in each DAI category and ABO-DI scores. Fifty-nine patients (49.2%) had ≥4 incisal segments with crowding.

Twenty-eight patients (23.3%) had ≥4 mm largest anterior irregularity on the maxilla. thirty-one patients (25.8%) had ≥4 mm largest anterior irregularity on the mandible. In a study conducted by Chauhan et al[12] on school-going children in 12 districts of Himachal Pradesh, it was found that 977 (82.2%) school-going children had no incisal segment crowding and 211 (17.8%) school-going children had one or two segment crowding. No statistically significant differences were observed in the occurrence of largest anterior irregularity on the maxilla and mandible when the prevalence was compared between males and females.

These irregularities could be crowding, presence of supernumerary teeth or retained deciduous teeth, and a retrognathic mandible, that is, the smaller size of the mandible and normal-sized teeth result in irregularity of teeth, leading to malocclusion.

Spacing in Incisal Segments and Midline Diastema

No statistically significant difference was reported between spacing in the incisal segments and midline diastema in each DAI category and ABO-DI scores. Thirty-seven patients (30.8%) had ≥4 incisal segments with spacing. Two patients (1.7%) had ≥3 mm midline diastema. A study conducted by Chauhan et al[12] on school-going children in 12 districts of Himachal Pradesh found 1,170 (98.5%) school = going children had no incisal segment spacing and 18 (1.5%) school-going children had one or two segment spacing. The various reasons leading to spacing in incisal segments are found to be one or more missing teeth, any oral habit, for example, tongue thrusting or thumb sucking, microdontia, high frenal attachment, presence of mesiodens or increased dental arch length due to greater size of the underlying skeletal bases, which could be due to some hormonal imbalance or hybrid generations or impacted canine or deviated path of eruption of the canine, proclination of the anterior teeth, hypotonic upper lip, greater tongue pressure, and the presence of a thick frenum.

Anterior Maxillary Overjet and Anterior Mandibular Overjet

No statistically significant difference was reported between anterior maxillary overjet in millimeters and anterior mandibular overjet in millimeters in each DAI category and ABO-DI scores. Eighty-two patients (68.3%) had ≥4 mm anterior maxillary overjet. Anterior mandibular overjet represents underbite or reverse or negative overjet, which is a common feature of class III malocclusion. Six patients (5%) had greater than or equal to –1 mm anterior mandibular overjet. A study conducted by Chauhan et al[12] on school-going children in 12 districts of Himachal Pradesh found that 757 (63.7%) children had an anterior maxillary overjet of 0 to 2 mm and 431 (36.3%) had an overjet of greater than 2 mm. A total of 1,173 (98.7%) children had no mandibular overjet and 15 (1.3%) had a mandibular overjet of 1 to 2 mm. In a study conducted by Plaza et al[6] on the population of Colombia, an association was found between anterior maxillary overjet and mandibular overjet and ABO-DI scores ($p = 0.0001$). Increased anterior maxillary overjet could result because of several factors, including various oral habits, for example, tongue thrusting, thumb sucking, lip sucking, which can exaggerate the overjet, tongue pressure, hypotonic upper lip, arch length–tooth size discrepancy, or skeletal discrepancy in which there could be prognathic maxilla, retrognathic mandible, or a combination of both.

The presence of anterior mandibular overjet or negative overjet could be due to skeletal discrepancy between the maxillary and mandibular jaw bases, which could be a discrepancy in size or position of the jaw bases in which there could be a retrognathic maxilla, prognathic mandible, or a combination of both; congenitally missing maxillary lateral incisors, which alter Bolton's ratio, presence of congenital defects, for example, cleft lip and palate, or mandibular functional shift (pseudo-class III). The reason for anterior mandibular overjet in our present study was a discrepancy between the jaw bases.

Vertical Anterior Open Bite

No statistically significant association was reported between vertical anterior open bite (DAI category) and ABO-DI scores.

Two patients (1.7%) had greater than or equal to –4 mm vertical anterior open bite. A study conducted by Chauhan et al[12] on school-going children in 12 districts of Himachal Pradesh found that out of 1,188 examined school children, 10 (0.8%) children had an anterior open bite of greater than or equal to –1 mm. In a study conducted by Shivakumar et al[17] on 12- to 15-year-old school children studying in middle and high schools of Davangere city, Karnataka, India, it was found that out of 1,000 school children examined, 21 (2.1%) children had –1 to 3 mm of anterior open bite. Vertical anterior open bite could result because of a number of factors, for example, oral habit such as thumb sucking or tongue thrusting, mouth breathing resulting in intruded upper and lower anterior teeth, extruded upper or lower posterior teeth, anticlockwise inclination of the maxilla, clockwise rotation of the mandible, or vertical growth pattern. The reason for vertical anterior open bite in our present study was the presence of oral habit, mainly thumb sucking.

Anteroposterior Molar Relation

A statistically significant difference was reported between the anteroposterior molar relation in each DAI category and the ABO-DI scores ($p = 0.0001$). In all, 51.7% had a normal cusp anteroposterior molar relation. Twenty-seven patients (22.5%) had a half-cusp anteroposterior molar relation. Thirty-one patients (25.8%) had a full cusp anteroposterior molar relation. The varied reasons for an altered anteroposterior molar relation could be either skeletal or dental. Skeletal causes could include skeletal jaw base discrepancy either due to the size or position of the jaw bases relative to each other. Dental causes could include mesial drift of permanent molars because of early exfoliation of the primary teeth, that is, the second deciduous molar. The reason for the anteroposterior molar relation in our present study was the skeletal jaw base discrepancy and mesial drift of the first molar due to the absence of an adjacent premolar.

Conclusion

A statistically significant difference was reported between the DAI parameters, that is, the anteroposterior molar relation and ABO-DI scores. This indicates that there will be an increase in the ABO-DI scores if there is an increase in the anteroposterior molar relation score. The IMPA angle had the highest influence on the ABO-DI score, whereas the anterior open bite had the least influence.

The reason for the high malocclusion scores in our study was the selection of the study sample from patients with malocclusion attending the OPD of the orthodontic department. Other compared studies derived their sample size from a random population. A moderate positive correlation was reported (0.426) between the ABO-DI and DAI scores, with statistical significance ($p = 0.000$).

Conflict of Interest
None declared.

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